The effect of serial correlation on reservoir capacity using the modified Gould's probability matrix method (MGPM)

FAO Otieno[1]* and JG Ndiritu[2]

[1] *Department of Civil Engineering, University of Durban Westville, Private Bag X54001, Durban 4000, South Africa*
[2] *Department of Civil and Environmental Engineering, University of Adelaide, SA, 5005, Australia*

Abstract

The effect of serial correlation of inflows on estimating the reservoir capacity using the modified Gould's probability matrix method was investigated using the historical monthly streamflow sequences of 6 potential reservoir sites in Kenya. The ratios of the capacities determined using the starting months of analysis, giving the maximum to those determined using the starting month of analysis and giving the minimum lagl annual serial correlation coefficient for each flow sequence, were used as the indicators of this effect. This approach was adapted after it was observed that the correlation coefficients varied highly with the starting month of analysis. Average ratios of 1.02,0.91,0.85 and 0.76 were obtained at the 30,50,70 and 90% draft levels respectively. Serial correlation therefore had an effect for drafts greater than 30% of the mean flow and this effect increased with the draft. It has therefore been recommended that the starting month of analysis giving the minimum annual serial correlation coefficient should be applied when using the modified Gould's probability matrix (MGPM) method if the demand is greater than 30% of the mean flow. It is likely that the same recommendation could be as valid for other capacity determination methods that assume independence of annual flows. The minimum serial correlation coefficients for 5 of the 6 sites were however still considerable with 4 of them being greater than 0.1 and the maximum being 0.349. Using the starting month of analysis giving the minimum annual serial correlation coefficient may therefore not adequately prevent the risk of an underdesign of reservoir capacity. It has been proposed that a method similar to the MGPM method but which routes the reservoir contents for periods longer than the one year used in the MGPM method has the potential to adequately check the serial correlation problem. The requirement is that the period should be long enough to give an insignificant correlation coefficient with one of the starting months of analysis that could be applied with that period. A 2-year period has been found to give practically insignificant correlation coefficients with 5 of the 6 streamflow sequences.

Introduction

The reservoir capacity determination problem involves the computation of the capacity of a reservoir required to meet specific water demands. The main components of a typical problem are illustrated in Fig. 1. As shown in the figure, the sources of water into the reservoir are the streamflow sequence Q_t, and the rainfall R_t on the reservoir. The main losses are the evaporation E_t and infiltration I_t through the reservoir bottom and the dam. It is usually assumed that the historical streamflow, rainfall and evaporation series at the site are satisfactory representatives of the respective series during the life of the reservoir. The historical records or sequences generated from them are therefore used in the analysis. The capacity C of the reservoir which is required to meet the demand D_t and also satisfy the downstream water rights DOR_t needs to be determined. Some reservoir capacity determination methods associate the capacity with a reliability R_e which is usually quantified by the probability of failure P_f using the relationship $R_e = 1-P_f$. A common definition of probability of failure is the probability of emptiness of the reservoir. With some methods, it is also possible to associate the capacity with the volumetric reliability defined as the proportion of water actually supplied to that which was demanded in the simulation period. Beshay and Howell (1986) have proposed other measures of the hydrologic performance of reservoir in addition to volumetric reliability.

In comprehensive reviews of river and reservoir yield, (McMahon and Mein,1978; 1986), reservoir capacity determination methods have been broadly classified into critical period, Moran theory-based techniques and methods based on stochastically generated data. The third class involves the use of stochastically generated data with methods of the first two classes. The basis of critical period techniques, is the simulation of the reservoir through the low-flow periods, usually termed the critical periods. Some critical period procedures such as Mass curve and the Sequent peak algorithm run through the streamflow data and select the single most serious critical period. The design capacity is then computed as the size just adequate to ensure that the demand will be met up to the end of this critical period. Consequently, these methods do not associate the capacity with a reliability level. Another set of critical periods that include Alexander's method, Dincer's method and the frequency mass curve analysis (partial duration series analysis) uses the historical

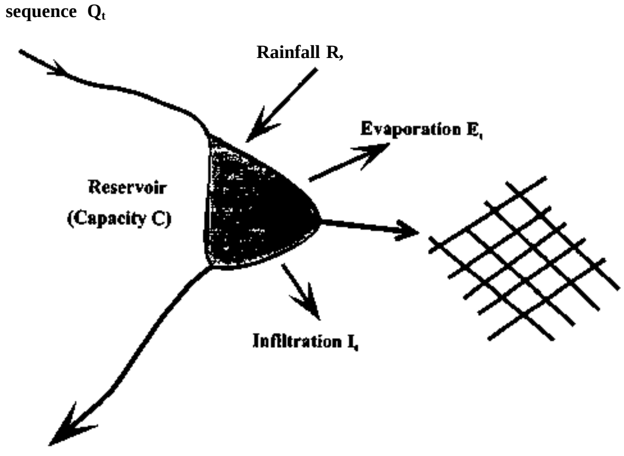

Figure 1
The reservoir capacity determination problem

* To whom all correspondence should be addressed.
☎(031) 8202709; fax (031) 8202755; e-mail: otieno@pixie.udw.ac.za
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